

**Demonstrate understanding of bonding, structure, properties
and energy changes
AS91164**

You are advised to spend 60 minutes answering the questions in this section

QUESTION ONE (Answer p13)

- (a) Draw the Lewis structure for each of the following molecules.

Molecule	CH ₄	H ₂ O	N ₂
Lewis structure			

- (b) Boron and phosphorus both bond with three fluorine atoms to form BF₃ and PF₃. However, the molecules have different shapes and bond angles.

The following table shows the Lewis structures for the molecules BF₃ and PF₃.

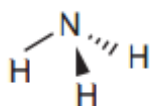
Molecule	BF ₃	PF ₃
Lewis structure	$\begin{array}{c} \text{:}\ddot{\text{F}}\text{--}\text{B}\text{--}\ddot{\text{F}}\text{:} \\ \\ \text{:}\ddot{\text{F}}\text{:} \end{array}$	$\begin{array}{c} \text{:}\ddot{\text{F}}\text{--}\text{P}\text{--}\ddot{\text{F}}\text{:} \\ \\ \text{:}\ddot{\text{F}}\text{:} \end{array}$

Explain why these molecules have different shapes and bond angles.

In your answer include:

- the shapes of BF₃ and PF₃
- factors that determine the shape of each molecule
- the approximate bond angle in BF₃ and PF₃
- justification of your chosen bond angles for each molecule.

- (c) (i) The 3-dimensional diagram of NH₃ is shown below.



Circle the word that describes the **polarity** of the molecule NH₃

polar

non-polar

Justify your choice.

- (ii) Elements M and X form a compound MX_2 . Atoms of element X have a higher electronegativity value than atoms of element M, therefore the M–X bonds are polar.

Depending on what elements M and X are, molecules of the compound formed will be

polar or **non-polar**.

State the most likely shape(s) of the molecule if it is:

Polar:

Non-polar:

Justify your answer and draw diagrams of the possible molecules with dipoles labelled.

You do not need to identify what elements M and X are.

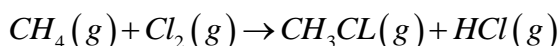
QUESTION TWO (answer p14)

- (a) Complete the table below by stating the type of substance, the type of particle, and the bonding (attractive forces) between the particles for each of the substances.

Substance	Type of Substance	Type of particle	Attractive forces between particles
C(s) (graphite)			
Cl ₂ (s) (chlorine)			
CuCl ₂ (s) (copper chloride)			
Cu(s) (copper)			

- (b) (i) Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature.
- In your answer, you should refer to the particles and the forces between the particles in **both** substances.
- (ii) Using your knowledge of structure and bonding, explain why, although both graphite and copper are good conductors of electricity, copper is suitable for electrical wires, but graphite is not.

(c) Chlorine reacts with methane to form chloromethane and hydrogen chloride, as shown in the equation below.

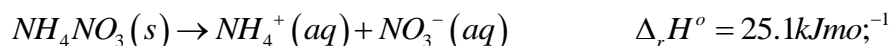


Use the following bond enthalpies to calculate $\Delta_r H^\circ$ for this reaction.

Bond	Bond enthalpy /kJ mol ⁻¹
H—Cl	431
C—H	414
C—Cl	324
Cl—Cl	242

QUESTION THREE (Answer p15)

- (a) Dissolving ammonium nitrate in a beaker containing water can be represented by the following equation:



Circle the term below that best describes this process.

exothermic

endothermic

Circle the description below that best describes what you would observe happening to the beaker during this process.

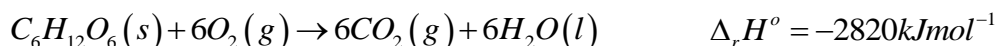
gets colder

stays the same

gets warmer

Explain your choices.

- (b) Glucose is an important source of energy in our diet. The equation below shows the combustion of glucose to form carbon dioxide and water.



- (i) Circle the term below that best describes this process.

exothermic

endothermic

Give a reason for your choice.

- (ii) Females who are moderately active need 9800 kJ of energy per day.

Calculate the number of moles of glucose that would provide this daily energy requirement.

- (c) (i) Many portable BBQ and camping gas canisters contain butane, C₄H₁₀. Butane is a gas at room temperature, and has a boiling point of -0.5°C . The gas canisters contain both gas and liquid butane. As the gaseous butane is used, some of the liquid evaporates.

Circle the term below that best describes this process.

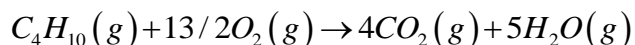
exothermic

endothermic

Give a reason for your choice, and use your knowledge of structure and bonding, and

energy changes, to explain the changes occurring as the liquid evaporates.

(ii) The equation below shows the combustion of butane.

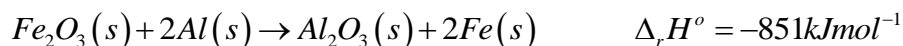
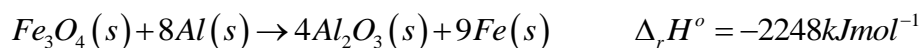


When 100 g of butane undergoes combustion, 4 960 kJ of energy is released.

Calculate the enthalpy change when 1 mole of butane undergoes combustion.

$$M(C_4H_{10}) = 58.1 \text{ g mol}^{-1}$$

(d) The iron oxides Fe_3O_4 and Fe_2O_3 react with aluminium as shown below.



Justify which iron oxide, Fe_3O_4 or Fe_2O_3 , will produce more heat energy when 2.00 kg of iron is formed during the reaction with aluminium.

Your answer should include calculations of the heat energy produced for the given mass of iron formed.

$$M(Fe) = 55.9 \text{ g mol}^{-1}$$